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(54) **Electrical apparatus enclosure with cooling air circulated in a closed path**

(57) An electrical apparatus enclosure comprises an inner enclosure (20) for housing electrical apparatus (30), and a heat exchanger having a heat exchanging passageway for carrying air in a closed path to and from the inner enclosure (20). The apparatus enclosure preferably comprises a plurality of side walls (50) which define the inner enclosure (20). Preferably at least one of the side walls comprises the heat exchanger. The apparatus enclosure may comprise a plurality of heat exchangers having air from the inner enclosure circulated through them by a fan (60, figure 2). The cooled air from the heat exchanger/s is preferably returned to the inner enclosure through an outlet (100) adjacent the electrical apparatus. The air from the enclosure is preferably cooled by ambient air driven through the heat exchanger by another fan (130). The speed of the fans may be controlled in dependance on the sensed air temperature. An air heating element may also be provided.

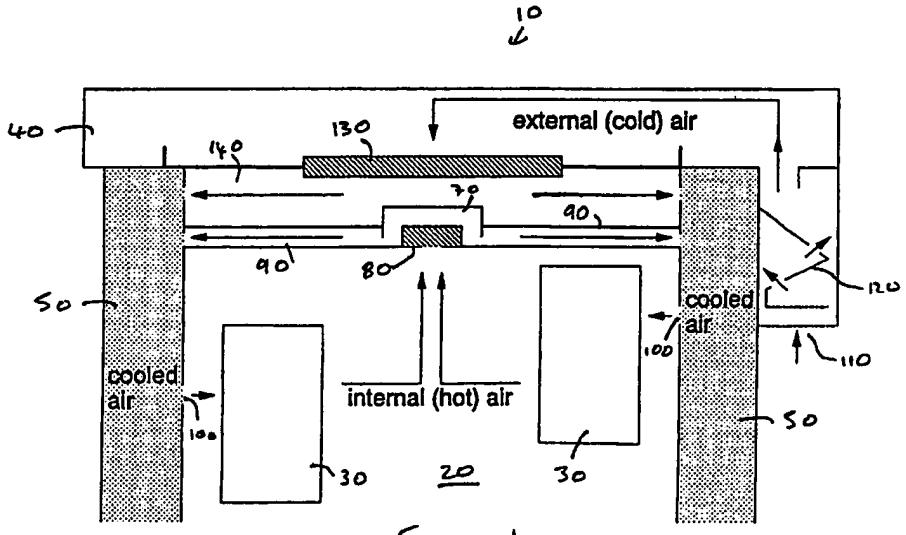

FIGURE 1

GB 2 284 659 A

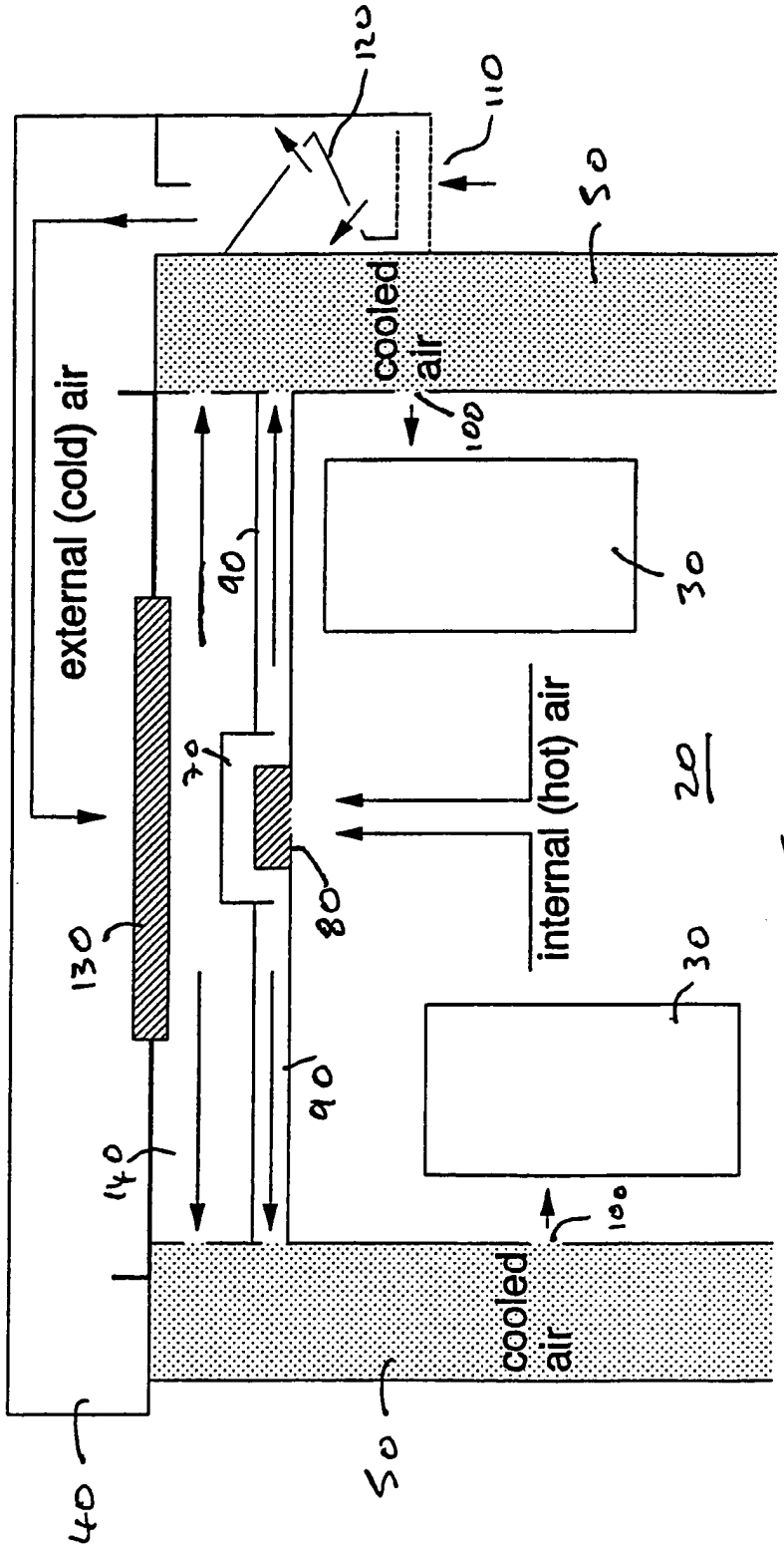
10
120
110
50
cooled air
100
external (cold) air
40
90
30
70
80
internal (hot) air
20
130
140
90
30
100
cooled air
50

FIGURE 1

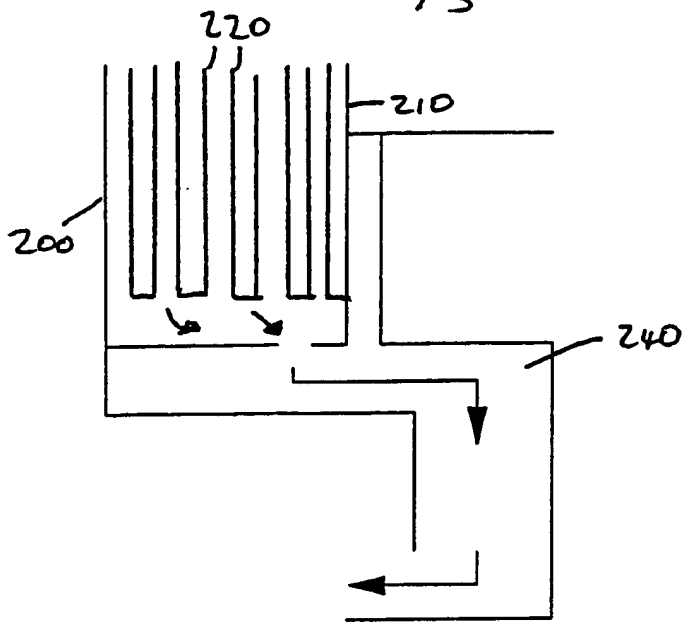

FIGURE 4

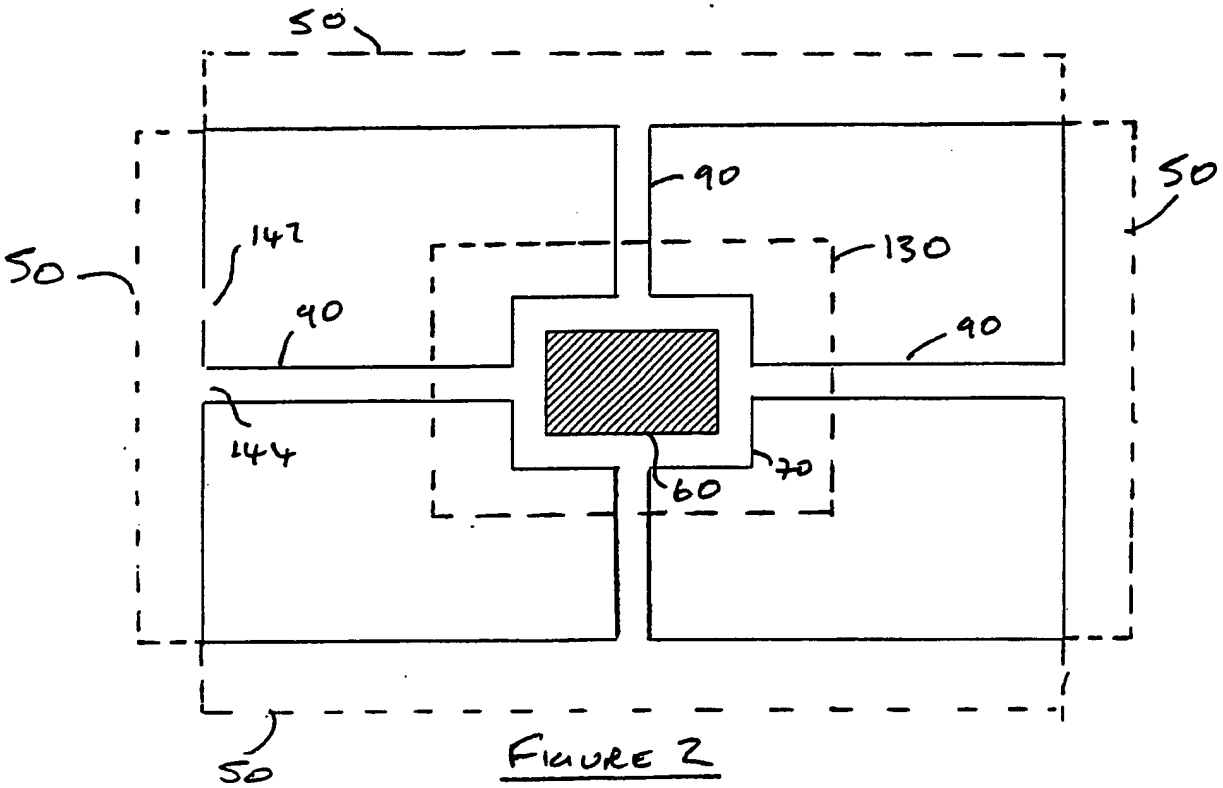

FIGURE 2

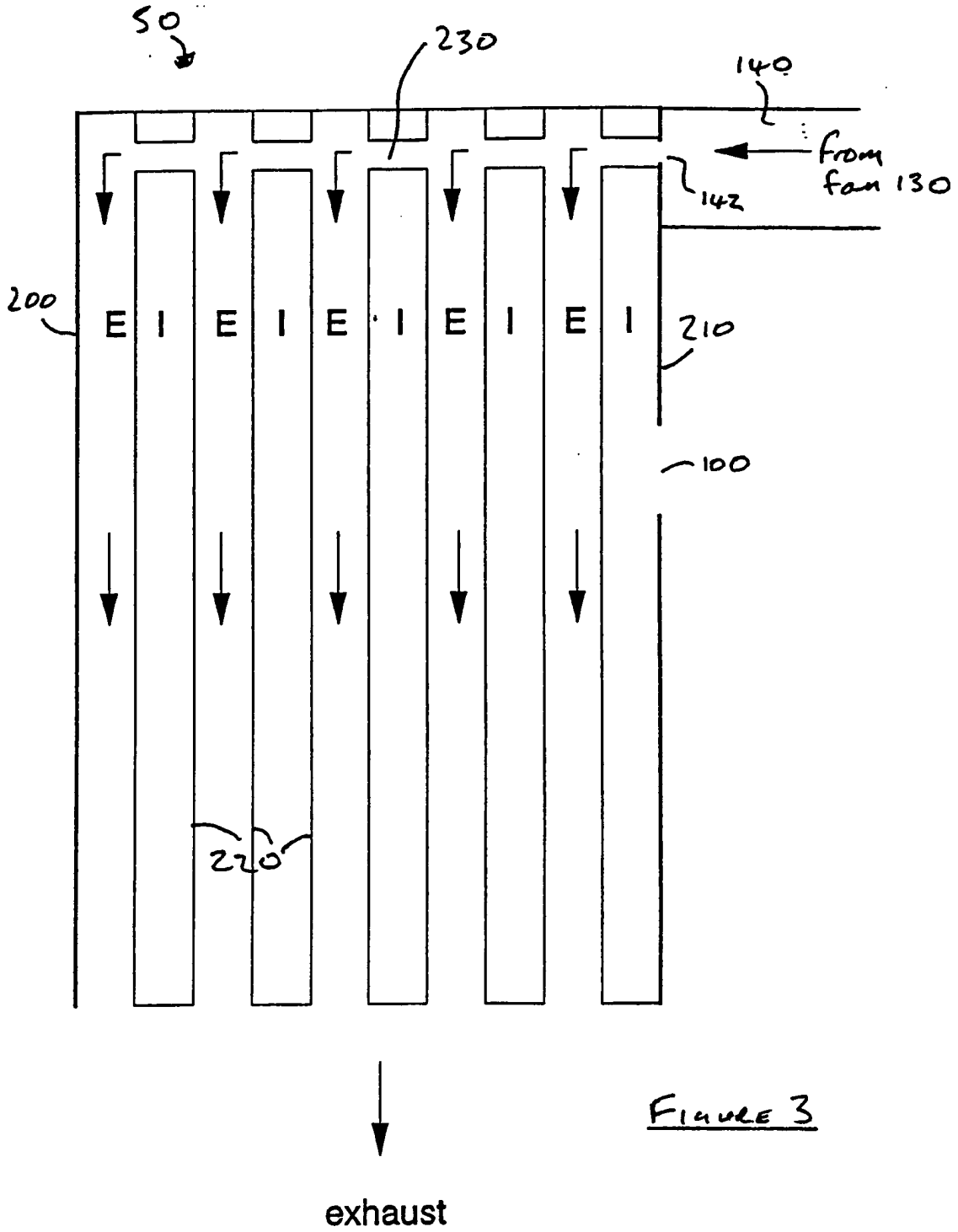
50
230
140
From fan 130
142
200
E I E I E I E I E I
210
100
220
exhaust

FIGURE 3

415

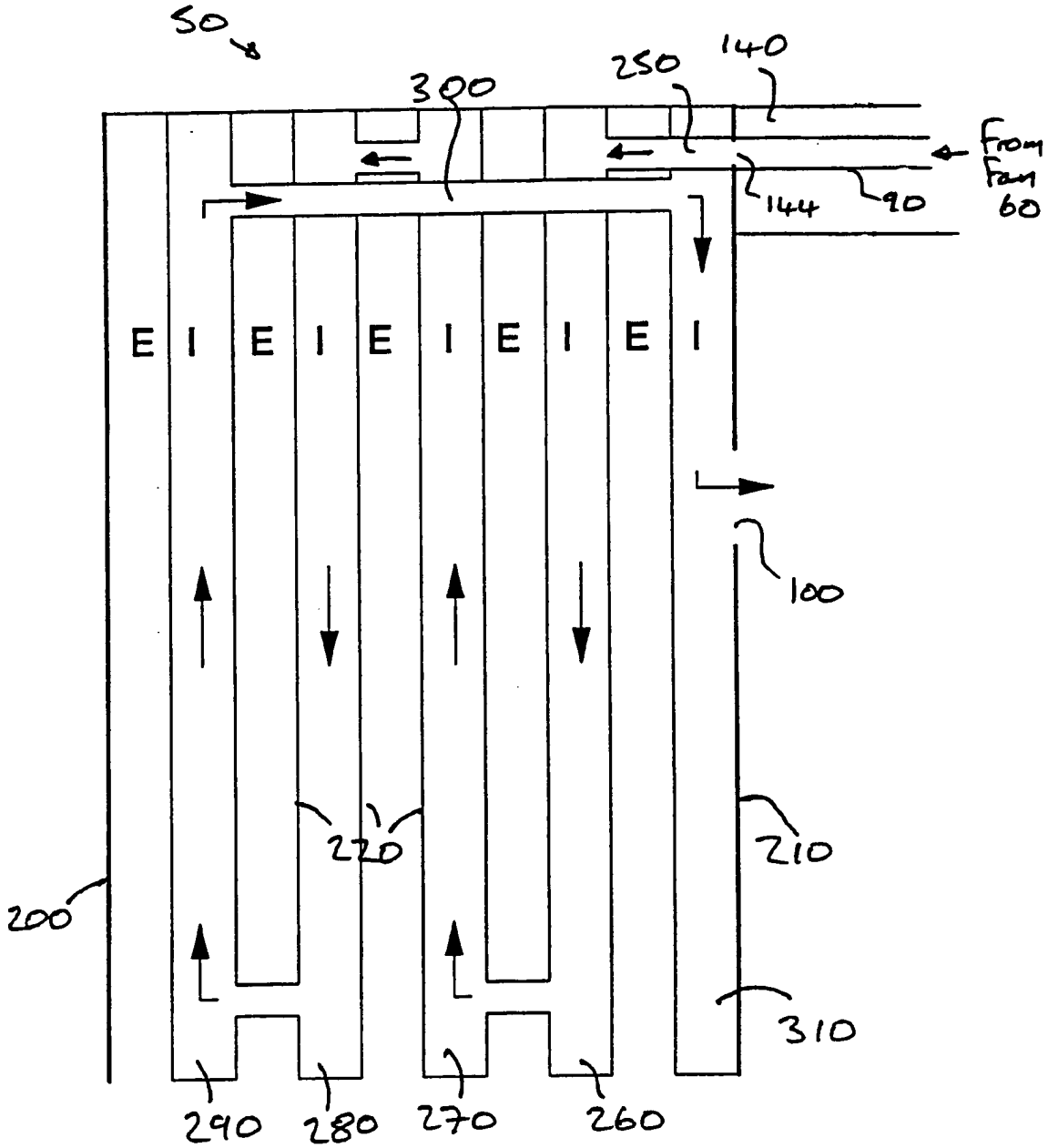
50
300
250
140
From Fan 60
144
90
E I E I E I E I E I
100
220
210
200
310
290
280
270
260

FIGURE 5

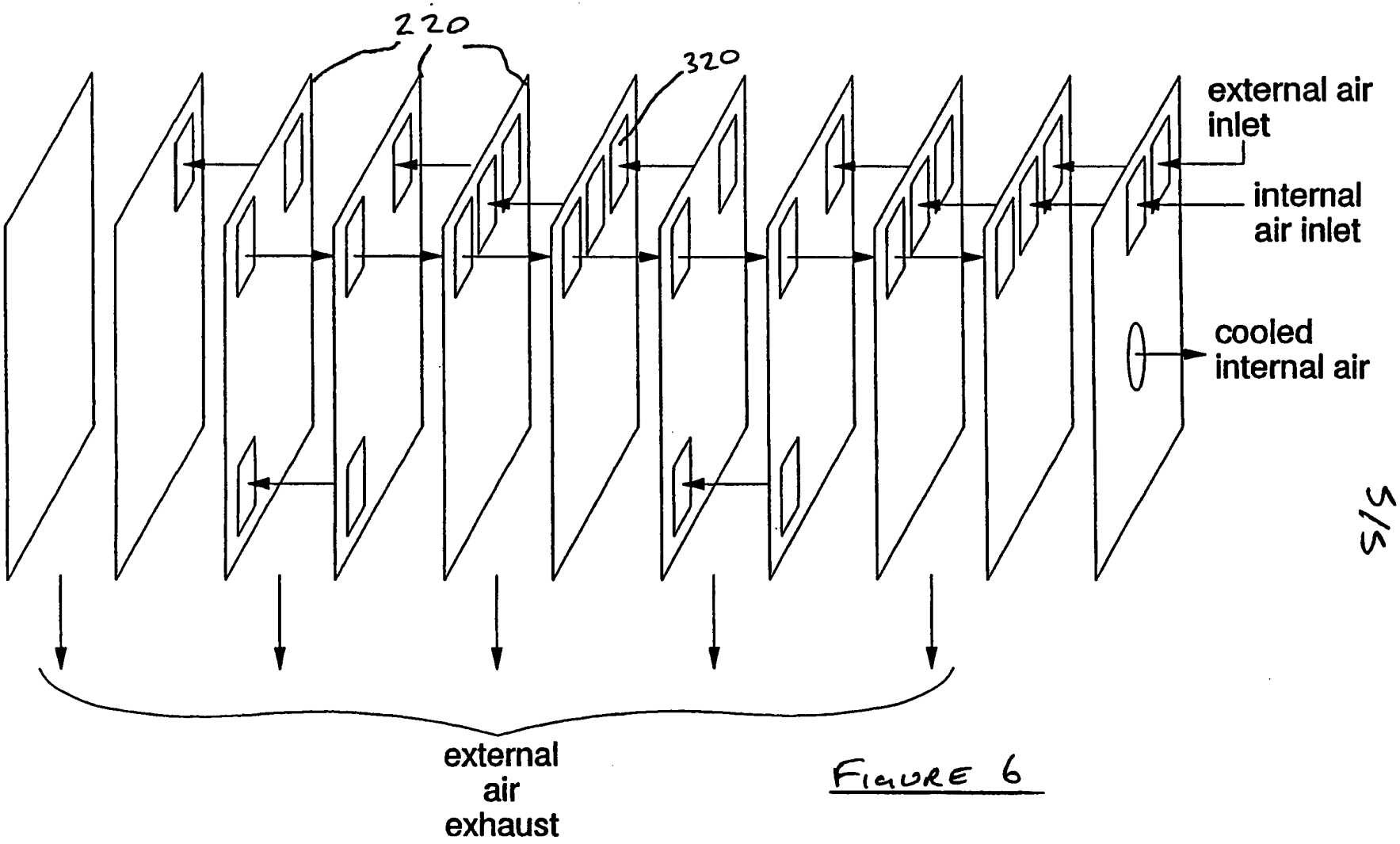
220
320
external air inlet
internal air inlet
cooled internal air
external air exhaust

FIGURE 6

ELECTRICAL APPARATUS ENCLOSURE

This invention relates to electrical apparatus enclosures.

It is known to provide electrical apparatus enclosures for installation in harsh outdoor locations. The electrical apparatus housed within the enclosures can be of many forms, such as electronic communication apparatus, cable television apparatus or traffic signal control apparatus.

Enclosures of this type must protect the potentially delicate apparatus housed within the enclosures against the harsh surrounding conditions. In particular, the enclosures must be sufficiently robust to withstand accidental mechanical damage or vandalism and, particularly in the case of street-side enclosures, to protect against the ingress of air-borne dust or water. In addition, the electrical apparatus must be protected from extremes of temperature variation.

One previous approach to this problem has been to employ a sealed inner enclosure to house the electrical apparatus, and to mount a heat exchanger within the body of the enclosure to allow the transfer of heat from air within the inner sealed enclosure and cooling air taken from the surroundings of the enclosure. However, heat exchanges of this type are bulky items, and either dramatically reduce the volume of the enclosure available for housing the electrical apparatus or require that a much larger (and correspondingly more obtrusive) enclosure be used.

This invention provides an electrical apparatus enclosure comprising a plurality of side walls defining an inner enclosure for housing electrical apparatus, in which at least one of the side walls comprises a heat exchanger having a heat exchanging passageway for carrying air in a closed path to and from the inner enclosure.

The invention addresses the problems described above by employing one or more heat exchangers disposed in the side walls of the electrical apparatus enclosure. In this way, heat exchange can be carried out without the dramatic loss of useful space within the enclosure incurred by the use of conventional heat exchangers.

The term "side walls" may include the back and front of the enclosure, possibly including one or more hinged doors of the enclosure.

Preferably, for efficient cooling of the air from within the inner enclosure, the heat exchanger comprises one or more channels, adjacent to the heat exchanging passageway, for carrying air from outside the enclosure.

Preferably the heat exchanger comprises a plurality of channels for carrying air from outside the enclosure, the heat exchanging passageway being configured to pass adjacent to each of the plurality of channels.

It is preferred that forced air cooling is employed; to this end, it is preferred that the enclosure comprises a first fan for driving air from outside the enclosure through the one or more channels. Also, it is preferred that the enclosure comprises a second fan for driving air from the inner enclosure through the heat exchanging passageway. The fans may be shared between several heat exchangers, if more than one side wall of the enclosure is furnished with a heat exchanger. This allows for a generally quieter operation.

In order to avoid the ingress of water and other contaminants at the base of the enclosure, it is preferred that, in use, air flows through the one or more channels in a generally downward direction. Moisture trapping structures may also be employed.

In order to direct air which has been cooled by the heat exchanger to an appropriate position within the inner enclosure, it is preferred that the heat exchanger comprises an air outlet for venting air from the heat exchanging passageway into the inner enclosure, the air outlet being positioned adjacent to the electrical apparatus.

Preferably the enclosure comprises an electrical temperature sensor. This may be positioned, for example, to detect the temperature of the inner enclosure or of the ambient surroundings of the enclosure.

In order to avoid the formation of condensation or dew within the inner enclosure, it is preferred that the enclosure comprises an electrical heating device operable to heat the inner enclosure; and means, responsive to the temperature sensor, for controlling the heating device to heat the inner enclosure if the temperature sensor detects a temperature below a predetermined threshold temperature.

Similarly, it is preferred that the enclosure comprises means for controlling the operating speed of the first fan in dependence on the temperature sensed by the temperature sensor, and/or means for

controlling the operating speed of the second fan in dependence on the temperature sensed by the temperature sensor. This can allow the fan speed to be reduced (or even stopped) as the temperature drops, in order to reduce the cooling efficiency (and the fans' power consumption) when cooling is less necessary. The fan speeds may be reduced progressively when the temperature reaches a predetermined threshold.

Viewed from a second aspect this invention provides an electrical apparatus enclosure comprising: an inner enclosure for housing electrical apparatus; a plurality of heat exchangers, each defining a respective heat exchanging passageway for carrying air in a closed path to and from the inner enclosure; and a fan for driving air from the inner enclosure through the plurality of heat exchangers.

Viewed from a third aspect this invention provides an electrical apparatus enclosure comprising: an inner enclosure for housing electrical apparatus; a heat exchanger defining a heat exchanging passageway for carrying air in a closed path to and from the inner enclosure; and an air outlet for venting air from the heat exchanging passageway into the inner enclosure, the air outlet being positioned adjacent to the electrical apparatus.

The invention will now be described by way of example with reference to the accompanying drawings, throughout which like parts are referred to by like references, and in which:

Figure 1 is a schematic diagram of an upper portion of an electrical apparatus enclosure;

Figure 2 is a plan view of a fan chamber;

Figure 3 is a schematic diagram illustrating the flow of cooling air through a heat exchanger unit;

Figure 4 is a schematic diagram illustrating an air exhaust vent forming part of a heat exchanger unit;

Figure 5 is a schematic diagram illustrating the flow of internal (recirculated) air through a heat exchanger unit; and

Figure 6 is an exploded schematic diagram of a heat exchanger unit.

Referring to Figure 1, an electrical apparatus enclosure 10 comprises an inner enclosure 20 housing electrical apparatus 30, a pitched roof area 40 and heat exchanger units 50 forming the walls,

back and hinged doors of the enclosure 10. The enclosure 10 is suitable for use at a street-side location, housing for example electronic communication apparatus, cable television apparatus or traffic signal control apparatus.

The inner enclosure 20 forms a sealed, recirculating system with the heat exchanger units 50, so that there is no contact or communication between air originating inside the inner enclosure 20 and air from outside the enclosure 10.

In operation, air which has been heated by the electrical apparatus 30 is drawn by a fan 60 mounted in a fan casing 70, through vents 80 in the top of the inner enclosure 20, and along ducting 90 to the heat exchanger units 50. This "internal" air then passes through a closed path through the heat exchanger units 50 (to be described below) so that there is no contact or communication between the internal air and air from outside the enclosure 10. After being cooled in the heat exchanger units 50, the internal air re-emerges through apertures 100 positioned adjacent to the electrical apparatus 30.

"External" (cooling) air from outside the enclosure 10 is drawn in through an air inlet 110, and passes through a moisture trap 120 before being drawn by a fan 130 into a chamber 140. The external air passes from the chamber 140 into the heat exchanger units 50 and is exhausted through an exhaust vent (not shown) at the bottom of each heat exchanger unit 50.

Figure 2 is a schematic plan view of the chamber 140. In particular, Figure 2 illustrates the casing 70 housing the fan 60, and the ducting 90 leading from the fan casing 70 to the heat exchanger units 50. Thus, although the casing 70 is housed within the chamber 140, air from inside the inner enclosure 20 is kept separate from external air passing through the chamber 140 by the ducting 90. Figure 2 also shows the position of the fan 130 which draws air through the moisture trap 120 and the roof area 40, down into the chamber 140 and from there into the heat exchanger units 50.

In Figure 1, the apertures 142, 144 allowing the passage of internal and external air from the chamber 140 into the heat exchanger units 50 were shown schematically at different vertical positions for clarity of the diagram. In fact, as shown in Figure 2, these apertures are at the same vertical position but displaced horizontally from one

another.

Figure 3 is a schematic diagram illustrating the flow of cooling external air through the heat exchanger units 50. Each of the heat exchanger units 50 forms a side wall, a back wall or a door of the enclosure 10, and comprises an outer metal skin 200, an inner metal skin 210, and a plurality of vertical metal dividing plates 220. The dividing plates 220 define vertical passageways through which either internal (recirculating) air or external (cooling) air passes. The passageways are arranged so that alternate passageways carry internal air, with the remainder carrying external air. Figure 3 illustrates the flow of external (cooling) air from the fan 130 in the chamber 140, through a connecting aperture 142 and into the heat exchanger unit 50.

(The flow of internal air through the heat exchanger units 50 will be described below with reference to Figure 5.)

External air driven from the chamber 140 by the fan 130 enters a horizontal channel 230 linking alternate ones of the vertical passageways. The external air is thus divided between the vertical passageways and flows vertically downwards through alternate ones of the passageways. The air is then exhausted at the bottom of the heat exchanger unit 50 through a vent to the atmosphere.

Figure 4 is a schematic diagram of an air exhaust vent disposed at the bottom of each heat exchanger unit 50.

External air emerges at the bottom of the vertical passageways to pass through a chamber 240 horizontally displaced from the heat exchanger unit 50. This arrangement helps to prevent the ingress of moisture and dust into the heat exchanger unit by two means: the air emerging from the chamber 240 is (by definition) flowing outwards under pressure, and therefore acts against the inward passage of contaminants, and the chamber 240 acts as a moisture trap preventing, for example, water splashed from a passing vehicle from entering the heat exchanger unit 50 by a direct path.

Figure 5 is a schematic diagram illustrating the flow of internal (recirculating) air through the heat exchanger units 50.

The internal air passes through the ducting 90 into a channel 250 connecting the ducting 90 to one of the vertical passageways (260). The internal air then flows successively down through the vertical passageway 260, up through a vertical passageway 270, down through a

vertical passageway 280 and up through a vertical passageway 290. The air is then carried along a channel 300 into the vertical passageway 310 closest to the internal wall 210 of the heat exchanger 50. Finally, the internal air emerges through the aperture 100 positioned adjacent to the equipment 30 to be cooled.

Thus, the internal air follows a closed path from the ducting 90 to the aperture 100, running adjacent to several different passageways carrying external (cooling) air.

Figure 6 is an exploded schematic diagram of a heat exchanger unit 50, illustrating the dividing plates 220 and the relative positions of the channels linking the various vertical passageways (e.g. the channels 230, 250 and 300 in Figures 3 and 5).

In the present embodiment, each of the dividing plates 220 is approximately 1 metre x 0.5 metre, and the dividing plates are separated by a gap of about 4 millimetres (mm). Accordingly, the horizontal channels linking the various vertical passageways are formed by placing a ring of sealing or gasket material around apertures (for example, the aperture 320) in the plates before the plates are assembled into the heat exchanger unit 50. The rings of gasket material then seal against adjacent plates (or rings of gasket material on those plates) to form the horizontal channels. Alternatively, the horizontal channels could be formed by plastics extrusions slotted into the apertures in the dividing plates 220. The extrusions could be grooved to serve the additional purpose of holding the plates at the desired spacing.

When the ambient (external) temperature is low, the internal air is cooled more than when the ambient temperature is high. However, the temperature within the inner enclosure is regulated by employing an electronic temperature sensor (not shown) in the inner enclosure. The electronic temperature sensor is connected to a feedback control circuit to control the speed of one or both of the fans 70, 130. In this way, if the temperature within the inner enclosure drops to below a first predetermined level (e.g. 15° Celsius) then the speed of revolution of the fans is reduced (or the fans can be stopped completely), to reduce the flow of internal and external air through the heat exchanger units 50. The heat generated by the electrical apparatus 30 is then allowed to warm the inner enclosure 20 to prevent

the formation of condensation or dew. If the temperature of the inner enclosure still drops, however, and reaches a second (lower) predetermined level such as 5° Celsius, then an electrical heating element (not shown) mounted within the fan casing 70 is switched on to maintain a suitable operating temperature within the inner enclosure 20.

CLAIMS

1. An electrical apparatus enclosure comprising a plurality of side walls defining an inner enclosure for housing electrical apparatus, in which at least one of the side walls comprises a heat exchanger having a heat exchanging passageway for carrying air in a closed path to and from the inner enclosure.

2. An enclosure according to claim 1, in which the heat exchanger comprises one or more channels, adjacent to the heat exchanging passageway, for carrying air from outside the enclosure.

3. An enclosure according to claim 2, in which the heat exchanger comprises a plurality of channels for carrying air from outside the enclosure, the heat exchanging passageway being configured to pass adjacent to each of the plurality of channels.

4. An enclosure according to claim 2 or claim 3, comprising a first fan for driving air from outside the enclosure through the one or more channels.

5. An enclosure according to any one of claims 2 to 4 in which, in use, air flows through the one or more channels in a generally downward direction.

6. An enclosure according to any one of the preceding claims, comprising a second fan for driving air from the inner enclosure through the heat exchanging passageway.

7. An enclosure according to any one of the preceding claims, in which the heat exchanger comprises an air outlet for venting air from the heat exchanging passageway into the inner enclosure, the air outlet being positioned adjacent to the electrical apparatus.

8. An enclosure according to claim 4, comprising an electrical temperature sensor.

9. An enclosure according to claim 8, comprising:

an electrical heating device operable to heat the inner enclosure; and

means, responsive to the temperature sensor, for controlling the heating device to heat the inner enclosure if the temperature sensor detects a temperature below a predetermined threshold temperature.

10. An enclosure according to claim 4 and any one of claims 8 and 9, comprising means for controlling the operating speed of the first fan in dependence on the temperature sensed by the temperature sensor.

11. An enclosure according to claim 6 and any one of claims 8 to 10, comprising means for controlling the operating speed of the second fan in dependence on the temperature sensed by the temperature sensor.

12. An electrical apparatus enclosure comprising:

an inner enclosure for housing electrical apparatus;

a plurality of heat exchangers, each defining a respective heat exchanging passageway for carrying air in a closed path to and from the inner enclosure; and

a fan for driving air from the inner enclosure through the plurality of heat exchangers.

13. An electrical apparatus enclosure comprising:

an inner enclosure for housing electrical apparatus;

a heat exchanger defining a heat exchanging passageway for carrying air in a closed path to and from the inner enclosure; and

an air outlet for venting air from the heat exchanging passageway into the inner enclosure, the air outlet being positioned adjacent to the electrical apparatus.

14. An electrical apparatus enclosure substantially as hereinbefore described with reference to the accompanying drawings.

Patents Act 1977 E niner's report to the Comptroller under Section 17 (1ue Search report)	Application number GB 9323979.6
Relevant Technical Fields (i) UK Cl (Ed.L/M) F4S (S41AS); F4U (U24A2); H1R (RBL, RBK) (ii) Int Cl (Ed.5) F28D (1/00, 7/00, 9/00); H05K (5/02, 7/20)	Search Examiner T M JAMES Date of completion of Search 19 JANUARY 1994
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ON-LINE: WPI	Documents considered relevant following a search in respect of Claims :- 1-14

Categories of documents

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Y:	Document indicating lack of inventive step if combined with one or more other documents of the same category.	E:	Patent document published on or after, but with priority date earlier than, the filing date of the present application.
A:	Document indicating technological background and/or state of the art.	&:	Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
X, Y	GB 1451920	(RYAZANOV & GUSEV) see page 3 lines 45-78	X: 1-7,12,13 Y: 8-10
X, Y	EP 0456398 A2	(AMERICAN TELEPHONE) see column 3 lines 10-33	X: 1,6,7,12, 13 Y: 8-10
Y	US 4813475	(COUVRETTE) see column 4 lines 20-35	8-10
X, Y	US 4488193	(IBM) see column 4 line 40 - column 5 line 6	X: 1-7,12,13 Y: 8-10

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